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ABSTRACT

The research in this paper explores the possibilities of challenging preservice teachers' mathematical beliefs through a specifically designed early field experience intended to encourage both reflective analysis and instructional skill acquisition. The subjects in this one-semester study were 25 preservice elementary teachers at a small, private, liberal arts college in north-central Indiana. The study involved collecting data by administering three mathematical beliefs inventories, observing classroom teaching episodes, analyzing students' written lesson plans and reflective evaluation reports, and conducting interviews with selected preservice teachers and their respective supervising classroom teachers. The theoretical framework of this research was based on the premise that beliefs and practices are not linear-causal but are more interactive in nature. Results indicated that key beliefs do influence choices of content and methods in instructional settings and that particular aspects of a first teaching experience have differential effects on beliefs related to personal teaching efficacy, curriculum content, roles of teacher and student, and appropriate learning tasks. Contains 24 references. (MKR)

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MATHEMATICAL BELIEFS IN AN "EARLY TEACHING EXPERIENCE"

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BACKGROUND

In recent years, investigations of mathematical performance have considered more than just knowledge, facts, concepts, and procedures. It is now recognized that control decisions and processes (Garofalo & Lester, 1985), beliefs about the nature of mathematics (Schoenfeld, 1987), and attitudes and other affective variables (Reyes, 1984; McLeod, 1991) have tremendous effects on mathematical performance. Students often have conceptions about the subject matter they study and themselves that affect the decisions they make in learning mathematics and ultimately in their mathematical achievement.

Likewise, the nature of teachers' beliefs about the subject matter and about its teaching and learning may well play an important role in shaping their instructional practices. Fennema (1989) and Fennema and Franke (1992), for example, have proposed models to guide research on learning behaviors and the development of teachers' knowledge. In each model, the development of autonomous learning behavior for students and the contextual development of teachers' knowledge, including, content knowledge, pedagogical knowledge and knowledge of learners cognitions, are heavily influenced by internal beliefs.

Since the mathematical beliefs and dispositions of teachers may have far-reaching effects on their pupils, the study of the beliefs of in-service and preservice teachers has emerged in recent years as an important, legitimate area for research and its potential for making important contributions in mathematics education is becoming widely recognized. Key question being asked include: How do beliefs form? How do they evolve? How do people modify their beliefs? A number of studies have shown that the implementation of nontraditional teaching methods and experiences within a teacher education program holds promise for modifying the beliefs of preservice teachers and content, learning, and pedagogy (Santos, 1993; Benbow, 1993). These methods and experiences are usually integral parts of a program specifically designed to cause preservice teachers to become aware of and reflect upon their own mathematical beliefs.

One component of teacher preparation that is common to virtually all programs and appears to be a potentially powerful force in influencing preservice teachers' beliefs is the early field experience. However, the research on their effectiveness is unclear. Zeichner (1980) points out that early field experiences can be helpful or in some cases harmful to preservice teachers. In some cases, PSTs develop a sense of autonomy, creativity, and thoughtfulness during the field component, while others become less flexible in their thinking and simply imitative of teaching routines. Also, what prospective teachers have learned in early field experiences has depended upon a number of variables (Goodman, 1985). In addition, little is known about the complex interactive

relationship between preservice teachers' mathematical beliefs and their classroom practice that occurs in these early field experiences. Evidence indicates that not only do teachers' beliefs and pedagogical content knowledge influence their classroom practice but that the relationship also holds in the reverse. This relationship appears to be dialectical (Cobb, et al, 1991). Although some research has focused on the student teaching experience, little has been done to investigate the differentiated effects of early field experiences on individual prospective teachers or to describe the complexity of the interaction between their classroom teaching and mathematical beliefs.

Since the term "early field experience" is especially broad and since these experiences can vary widely from one program to another, the most fruitful studies might be those focused on specific field experience programs. Particular types of early field experiences might likely be influential on beliefs about mathematics, mathematical learning and teaching, and on the building of self-confidence in teaching mathematics. Through the examination of specific models, built on sound theoretical frameworks and implemented in appropriate contexts, we may learn not only about the nature of teachers' thinking but also about effective program structures for early field experiences.

Some studies have shown that field experiences appearing to have the greatest potential for fostering professional development have been highly structured (Bonar, 1985), and built on a type of "reflective practitioner" model (Goodman, 1985; Roth, 1989; Armaline & Hoover, 1989). Although specific applications of this model may differ, a central element in each is the idea of "inquiry-oriented" teacher education where students are encouraged to think critically about what, why, and how one does things (Schon, 1983; Posner, 1993; Roth, 1989).

The specific early field experience program examined in this study incorporates elements of the "reflective practitioner" models as well as opportunities for "skill acquisition" (Cruickshank & Metcalf, 1990), in a highly structured and personalized setting. The experience emphasizes successful practice teaching and is currently implemented as part of mathematics content-methods courses at a private, midwestern, liberal arts university. The goal of this study was to examine the influences of an intensive, early field experience that is built on elements of both "reflective-teacher" and "teacher training" principles on the mathematical beliefs of preservice elementary teachers. The analysis of the data is pointed toward providing insights not only into the nature of teachers' beliefs and practices, but also into effective means for structuring teacher preparation programs.

The Study

Theoretical Framework

The current literature supports the notion that the relationship between beliefs and practice is complex, involving a give and take between them and, thus, is dialectical in nature. This is contrary to the assumption of linear causality, where first come the beliefs and the practice follows, that appears to underlie earlier investigations. Cobb et al. (1990) have noted that in their view, arguments about the direction of the assumed causality miss the point and that "the very nature of the relationship needs to be reconceptualized." There is not doubt that research supports the claim that beliefs do influence classroom practice. These beliefs serve as filters through which teachers interpret and give meanings to their school experiences. But, at the same time, many of the teacher's beliefs seem to originate and be shaped by the experiences of interacting with children and subject matter in the classroom. As Thompson (1992) has noted in her review of this research: "By interacting with their environment, with all its demands and problems, teachers appear to evaluate and reorganize their beliefs through reflective acts, some more than others." It is by reflecting on their views and actions that teachers gain an awareness of their tacit assumptions and beliefs and how these relate to their practice. Through reflection, teachers may develop coherent rationales for their views and actions and become aware of alternative views and actions. In light of this, Ernest (1988) has speculated that by reflecting on the effect of their actions on students, teachers develop a sensitivity for context that enables them to select and implement situationally appropriate instruction. The early teaching experience that was the context of this study is intentionally designed to challenge preservice teachers to reflect on their beliefs and practices as they interact with elementary children in real classrooms.

The study was designed to gain insights into several related questions about the PST's mathematical beliefs and this initial classroom teaching experience:

1. What are the initial beliefs of the preservice teachers in regard to a) the nature of mathematics, b) how mathematics is learned, c) how mathematics is best taught, and d) themselves as teachers of elementary mathematics.
2. What influences do the mathematical beliefs of the preservice elementary teachers have on their decisions involving: a) lesson planning, b) classroom instruction, c) interaction with students and teachers, and d) the evaluation of their own performance?
3. What impact, if any, does the classroom teaching experience have on the mathematical beliefs of the preservice teachers in regard to: a) the proper role of the teacher in mathematics instruction, b) the proper role of the student in learning mathematics, c) appropriate instructional strategies in mathematics instruction, and d) the nature of and evaluation

of mathematics learning.

4. What aspects of, or experiences in, the early field component appear to be significant forces in shaping the mathematical beliefs of the preservice teachers?

RESEARCH METHODOLOGY

This study incorporated both quantitative and qualitative research methods. The procedures employed included the administration of Likert-type and open-ended beliefs scales, classroom observations of teaching, analysis of the participants' written reflective reports of their experiences, and audiotaped interviews of eight preservice teachers and their corresponding supervising classroom teachers. Initial analysis of some quantitative survey data occurred early in the semester and the remaining data were analyzed after the participants had completed the early field experience.

Setting

Each PST is responsible to teaching a math-lab type lesson (active hands-on, student involvement) in a local elementary school classroom once per week for about 11 or 12 weeks. During the first week of the semester, students are assigned to a specific classroom teacher (grade K-6) in one of two local elementary schools. All or almost all of the classroom teachers have previously participated in this field experience program, most for several years. The practice teaching is usually done in teams of two to four and provides preservice teachers with opportunities to write lesson plans, prepare materials, teach a mathematics lesson to an entire class, receive feedback on their teaching, and conduct self-evaluations.

After each teaching session, the preservice teachers must submit a 1-2 page report which is a summary and reflective analysis of the classroom experience. In this evaluative report, the preservice teachers address such issues as why they chose to do what they did, what their feelings are about the experience, what they learned from it, what they would like to change, what their current primary concern about their assignment is, etc. A key goal of this teaching field experience is to provide opportunities, in an authentic school classroom environment, for future teachers to confront and examine their current mathematical beliefs and practices.

Subjects

The subjects participating in the surveys were twenty-five preservice elementary teachers at Taylor University, a small, private, liberal arts college in north-central Indiana. These students, 5 males and 20 females, were enrolled in MAT 202, Mathematics for Elementary Teachers II, and a corresponding lab

(field experience) during the fall semester of 1994 (August - December).

Instruments

Three mathematical beliefs questionnaires were administered to all 25 participants at the beginning and at the end of the semester. These were developed and/or administered for three purposes: 1) to aid in the selection of a smaller sample of PSTs to be interviewed later, 2) to provide a means of pre- and post-experience statistical comparison of various mathematical beliefs, and 3) to provide a possible means of validation for the descriptive data.

One questionnaire, the *Indiana Mathematics Belief Scales (IMBS)* (Kloosterman & Stage, 1992), consists of six, 6-item Likert-type scales intended to measure students' content and motivational beliefs in these areas:

1. (EFFORT) Effort Can Increase Mathematical Ability
2. (WORD PROBLEMS) Word Problems are Important in Mathematics
3. (STEPS) There Are Word Problems That Cannot be Solved with Step-by-Step Procedures
4. (UNDERSTANDING) Understanding Concepts is Important in Mathematics
5. (DIFFICULT) I Can Solve Time-Consuming Mathematics Problems
6. (USEFULNESS) Mathematics is Useful in Daily Life

The second questionnaire, *Elementary School Mathematics Teaching Beliefs Inventory* (ESMTBI), was used to measure beliefs about learning and teaching mathematics. It was developed at Vanderbilt University (Witherspoon & Shelton, 1991) and addresses pedagogical, content, and curricular issues of mathematics education. Its five constructs measured by separate Likert-type subscales on the instrument are:

1. Sense of Personal Mathematics Teaching Efficacy
2. Sense of Universal Mathematics Teaching Efficacy
3. Beliefs about Elementary School Mathematics Content
4. Beliefs about Elementary School Mathematics Pedagogy
5. Beliefs about Learning Processes

The third survey administered was a revised and shortened version of a questionnaire developed and used by Schoenfeld (1989) for a study of high school students. It is designed to assess students' perceptions about mathematics and school practice, their views of school mathematics, and personal and scholastic performance and motivation. The items on this survey included Likert-type statements as well as open-ended questions.

Observations

Each of the 25 participants were observed several times during their early field experience (classroom teaching episodes)

and field notes taken, with particular attention to the eight subjects who were later interviewed.

Written Work

All field experience participants produced two types of written documents per week related to their teaching sessions. The preservice teachers wrote a lesson plan prior to each teaching episode. In addition, all 25 participants wrote weekly reflective reports on their teaching experiences. These documents were kept and analyzed at the conclusion of the EFE. These written lesson plans and reflective reports provided a broader picture of the preservice teachers' intended practices which the classroom observations did not always reveal. They also provided insight into the prospective teachers' interpretation of actual teaching practices and classroom events and gave indications of any shifts in their conceptions about mathematics or teaching.

Interviews

After the field experience had concluded, 2-3 audiotaped interviews were conducted with each of the "selected" subjects. Also, each of the corresponding eight supervising classroom teachers was interviewed to elicit their perspectives on the semester's classroom events. The content of these interviews, along with that of the documents and observation notes, was then analyzed for emergent themes relevant to the research questions.

RESULTS

As can be seen from Table 1, beliefs of the PSTs on learning and doing mathematics were generally neutral to positive on all the scales on each administration of the IMBS. Respondents also believed that understanding concepts (as opposed to simply memorizing algorithms) is important in learning mathematics and that mathematics is useful in everyday life. The Understanding and Usefulness scales received the highest means on both administrations.

It is also evident from Table 1 that the PST's beliefs were relatively stable through the semester. The paired-sample t-tests comparing scores indicate that there were no significant differences, except on the Difficult Problems scale, between the beginning and end of the semester. The significant decline on the Difficult Problems scale, measuring self-confidence in doing multi-step, time-consuming, non-routine mathematics problems, is difficult to interpret but I found no evidence that any such belief change was related to the early field experience component of the program. Overall, the results from the IMBS indicate that the PST's beliefs about learning and doing mathematics are slightly positive and relatively stable.

TABLE 1
INDIANA MATHEMATICS BELIEFS SCALES

Subscale	N	Mean (Pre)	SD (Pre)	Mean (Post)	SD (Post)	t score
EFFORT	24	21.88	3.70	20.42	4.50	1.21
WORD PROBLEMS	24	21.21	3.61	21.79	2.48	.92
STEPS	23	17.52	2.78	18.17	2.96	1.52
UNDERSTANDING	24	25.13	2.97	23.00	4.95	2.03
DIFFICULT PROBLEMS	24	21.75	3.27	19.17	3.95	4.80*
USEFULNESS	24	25.58	2.45	23.33	4.57	2.02

* $p < .001$

Results from the ESMTBI are displayed in Table 2 and indicate that the PSTs' beliefs about teaching and learning mathematics are neutral to positive on all scales. Four of the subscales, Universal Efficacy, Content, Learning, and Pedagogy, consisted of nine questions each making the possible range of scores 9 to 45. On these four scales, a mean of 27 indicates a response of Undecided and a mean of 36 indicates a response of Agree. While 3 of these scales reflect fairly neutral responses, the Pedagogy scale, measuring beliefs about what teachers should do to help students learn mathematics, consistently received the highest mean score. At least on paper, the PSTs seem fairly open to innovative and nontraditional teaching strategies to help their elementary pupils better learn mathematics. These stated beliefs, of course, do not necessarily translate into actual classroom practices, particularly if not supported by significant persons and other classroom conditions. No significant differences between the pre- and post-test mean scores were found in the population responses on these 4 scales.

Since the Personal Teaching Efficacy subscale consisted of 10 questions, scores could have ranged from 10 to 50 with a mean of 30 indicating an Undecided position and 40 reflecting an Agree position. On both administrations, subjects responded positively on this scale indicating that overall, the PSTs have a fairly high opinion of their ability to teach mathematics in such a way as to have a positive effect on their pupils' achievement. This is also the only scale on which the difference of means achieved a level of significance ($t=3.64$, $p<0.01$). While changes in the other constructs may or may not have occurred for individual subjects, only the PSTs' Personal Teaching Efficacy showed a marked increase from the beginning to the end of the semester for

the group as a whole.

TABLE 2
Elementary School Mathematics Teaching Inventory

Subscale	N	Mean (Pre)	SD (Pre)	Mean (Post)	SD (Post)	t-score
Personal Efficacy	25	35.18	5.29	38.10	5.74	3.64*
Universal Efficacy	25	26.64	2.63	27.42	2.55	1.28
Content	25	29.40	2.17	29.24	2.79	-0.29
Learning	25	29.36	2.29	28.64	2.25	-1.43
Pedagogy	25	33.28	2.73	33.42	2.52	0.44

* $p < 0.01$

Although the qualitative data is still being analyzed, several general themes have emerged from the interviews with the PSTs. Each interviewee considered the classroom teaching experience to be a highly significant event in his/her quest for learning to become a teacher. All PSTs were convinced that they had learned much through this experience, although they were not always able to identify what that specific knowledge was.

1. Pre-existing beliefs about mathematics teaching and learning played key roles in decisions the PSTs made in planning and implementing their mathematics lessons. Because the PSTs had considerable freedom in choosing the content of their lessons and the teaching methods, their conceptions of the content of elementary mathematics, the proper role of the teacher and pupil, appropriate teaching strategies, and the goals of elementary mathematics directly influenced their pedagogical choices.

Just as certainly as initial beliefs shaped classroom teaching practices for a PST, those experiences (really, the PST's interpretations of the instructional outcomes) shaped future classroom decisions and practices. When a PST utilized a particular teaching method such as cooperative grouping or manipulative use, the perceived level of success of this strategy usually predicted whether it would be repeated by the PST. Feedback the PST received from the elementary pupils, whether in

the form of comments, attitudes, behavior, or learning outcomes, was a powerful force in influencing the PST's beliefs about appropriate mathematics teaching/learning strategies.

2. There was no indication of change in PSTs' beliefs about the nature of the subject of mathematics or about their own abilities to do mathematics as a result of the EFE. Subjects' beliefs relating to such constructs as the usefulness of mathematics, the nature of mathematical problem solving, or what it means to be successful in mathematics, remained unaltered. This was not unexpected since the structure of the EFE did little, if anything, to challenge the PSTs' beliefs in these areas.

3. Beliefs most likely to be confronted and modified through this EFE related to pedagogical issues in teaching elementary mathematics. PSTs appeared to modify their corresponding beliefs as they struggled through such issues as the ability of all children to learn mathematics, the teacher's goal in mathematics education, and effective instructional strategies. Perhaps it was when the prospective teachers actually encountered problematic situations in the classroom, that they began to reflect on their own knowledge, beliefs, and practices and become more open to alternative points of view, as they searched for answers to questions they were asking themselves.

However, the most dramatic belief changes occurred in the area of "personal mathematics teaching efficacy." Although, by the end of the EFE, the PSTs were no more confident of the power and influence of teachers ***in general*** to affect students' mathematics achievement (universal teaching efficacy), they were more confident in ***their own*** ability to help students learn mathematics (personal teaching efficacy). This shift in confidence in teaching mathematics can be attributed to two main factors. One is the practice teaching episodes with the elementary children. PSTs saw that they "could actually do it (prepare and teach a good lesson) and the children learned." The second factor related, not to the EFE, but to the corresponding Math for Elementary Teachers course experiences. Through these course activities students had come to see that mathematics "could make sense" and that there were reasons for formulas and algorithms. This sense of better understanding the content of the material (and therefore better able to actually explain it to someone else) contributed significantly to the PSTs' belief changes in personal teaching efficacy.

4. Overall, the EFE was primarily a "confirming" experience for the PSTs. Existing, "weak" beliefs were often confirmed in the minds of the PSTs as they experienced the realities of classroom teaching. A common response was that "this teaching experience totally confirmed that I want to be a teacher." Likewise, many PSTs had read and heard about particular teaching methods that they had never experienced as a mathematics student or as a teacher (e.g. hands-on activities, integration of subjects, use of

technology or specific manipulatives, cooperative grouping). Their initial professed beliefs about these issues were in a state of "flux" and were not strongly held. Although, responses on belief scales can show the direction of one's beliefs, they do not always adequately indicate the strength with which such beliefs are held. Through the course of experimentation with these instructional strategies and evaluating the learning outcomes, PSTs often had these "weaker" beliefs confirmed.

On the other hand, since the PSTs had already formed many fairly stable mathematical and pedagogical beliefs before beginning the EFE, their "core" (central) beliefs experienced little change. It was the peripheral beliefs, that is, those less strongly held, that were subject to examination and modification, when any change did occur. When confronted with challenges to their beliefs about mathematics teaching or learning, rather than abandoning their overall perspective, it was much easier to simply make smaller accommodations to those overarching beliefs.

5. Mathematical beliefs were not the only factors that affected classroom practices. There were potentially many moderating forces at work within the practice teaching environment that ultimately helped shape the preservice teacher-pupil interactions. In some cases, a PST was not able to convert his/her beliefs into corresponding classroom practices due to a lack of mathematical or pedagogical content knowledge. If the PST did not possess the necessary grasp of certain mathematical content or the managerial skills to implement alternative instructional strategies, these constraints were insurmountable obstacles for translating professed beliefs into teaching behaviors. Thus, specific content and pedagogical knowledge
can be highly restrictive forces on the process of transforming beliefs into desired educational environments.

CONCLUSIONS

Although there have been few attempts to challenge preservice teachers' mathematical beliefs through field experiences, the possibility remains for extensive research that looks at specific field experience programs and their relation to individual's mathematical beliefs.

Recent studies that have looked at constructs found in genuine teacher change have identified such things as cultural climate, perturbation, vision, commitment, metaphor and beliefs, personal epistemologies, and reflection (Jakubowski, 1991; Shaw, Davis, & McCarty, 1991). The many and varied elements of the early field experience described in this study, particularly for novice teachers who are encountering their very first classroom teaching episodes, parallels some of those teacher-changing constructs and thus provides an appropriate context in which to study the interrelations between mathematical beliefs and

classroom involvement. More research is needed in specific **teacher preparation contexts** that focuses on the complex interactions linking various dimensions of teacher beliefs and instructional decisions and practices.

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